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(54) **Device for detecting abnormal heart muscle electrical activity.**

(57) A portable apparatus (26) and method for monitoring heart muscle electrical activity includes a plurality of electrical contacts (28a,28b,30a,30b) and a monitoring unit (36). The contacts (28a,28b,30a,30b) receive the electrical signals generated by the heart muscle of a patient (34) and transmit the signals to the monitoring unit (36). A reference axis (22) is established for each signal (10,18) by the monitoring unit (36). Predetermined portions of each signal (10,18) are then used by the monitoring unit (36) to identify the ST segment (20) of the signal which is then compared to the reference axis (22). Whenever a series of ST segments (20) exhibit an ST deviation (24) from the reference axis (22) which exceeds a predetermined threshold ST deviation (66), the monitoring unit (36) records data relating thereto which is used for diagnosis of myocardial ischemia.

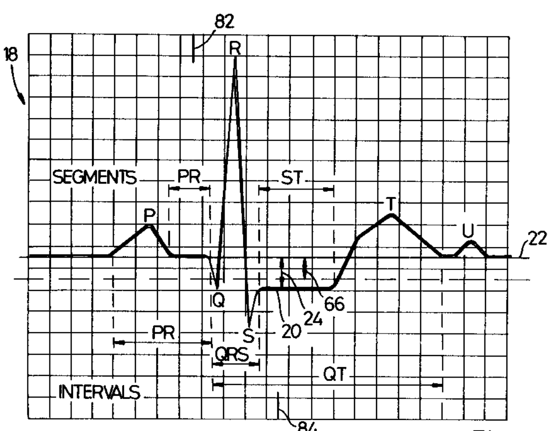

Fig. 2

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FIELD OF THE INVENTION

The present invention relates generally to monitoring heart muscle electrical activity. More particularly, the present invention relates to an apparatus and method for detecting abnormal heart muscle electrical activity. The present invention particularly, though not exclusively, relates to an apparatus and method for detecting myocardial ischemia by measuring deviations in the ST segment.

BACKGROUND OF THE INVENTION

A restricted blood supply to the heart muscle is a condition termed myocardial ischemia which is evidenced by abnormal heart muscle electrical activity. Untreated, myocardial ischemia can ultimately result in heart failure. As a result, monitoring of the electrical signals which stimulate the heart muscle is an invaluable diagnostic tool for determining the health of the heart and identifying abnormalities thereof.

When the electrical signal of a heart muscle is plotted over time, it defines a characteristic curve having a waveform which extends periodically above and below a horizontal reference axis conventionally termed the isoelectric line. Each elevation or depression of the signal curve above or below the reference axis respectively is termed a wave and is identified by a letter. There are a total of six waves in each period of the signal which are identified by the letters, P, Q, R, S, T, and U. A straight line connecting two waves of the signal curve is further identified as a segment, while a wave and connecting straight line is termed an interval. Segments and intervals are identified by various combinations of the above-listed letters.

A normal electrical signal of a healthy heart muscle is generally reflected in a regular curve having predictable PR and ST segments and PA, QRS, and QT intervals. Anomalous electrical signals of a heart muscle are reflected by deviations in specific portions of the curve from the predicted norm. Such deviations, and specifically deviations of the ST segment, may be symptomatic of myocardial ischemia.

Conventional electrical monitoring devices of the heart muscle are usually relatively immobile and complex to operate which requires them to be maintained in a central medical facility for operation by skilled personnel. As a result, outpatients at such facilities only receive monitoring periodically and for a short duration. However, diagnosis of myocardial ischemia generally requires the compilation of signal histories for an extended period of time which periodic monitoring does not provide.

Portable monitors for heart muscle electrical activity represent a potential solution to this problem. Unfortunately, satisfactory portable monitors have not been developed which are sufficiently small to enable full mobility of the patient, yet which are sufficiently sophisticated to enable continuous and reliable electrical monitoring of the patient in remote environments. As such, an electrical monitor is needed which specifically monitors electrical signals of the heart muscle and detects abnormal activity thereof. A monitor is needed which enables recording and displaying of relevant diagnostic data relating to anomalous heart muscle electrical signals. Further, such a monitor is needed which is portable, thereby enabling full mobility of the patient while providing continuous effective operation in remote environments.

SUMMARY OF THE INVENTION

The present invention provides a device for detecting abnormal electrical activity in the heart muscle of a patient. In one aspect, the invention provides an apparatus for monitoring heart muscle electrical activity of a patient characterised by comprising:

means positionable on the body of a patient for receiving electrical heart muscle signals generated by the patient;

means for establishing a reference axis relative to each of said signals;

means for identifying an ST segment in each of said signals;

means for measuring an ST deviation from said reference axis of each said ST segment and comparing said ST deviation to a predetermined threshold ST deviation; and

means for storing an anomalous ST deviation exceeding said predetermined threshold ST deviation. In a further aspect, the invention provides a method of employing a portable monitoring unit for monitoring heart muscle electrical activity, the method being characterised by comprising:

obtaining electrical heart muscle signals and transmitting said signals to said monitoring unit;

establishing a reference axis relative to each of said signals by means of said monitoring unit;

identifying an ST segment in each of said signals by means of said monitoring unit;

measuring an ST deviation from said reference axis for each said ST segment and comparing said ST deviation to a predetermined threshold ST deviation by means of said monitoring unit; and

storing an anomalous ST deviation exceeding said predetermined threshold ST deviation by means of a memory within said monitoring unit. A device according to a preferred embodiment of the invention thus comprises a plurality of electrical contacts and a self-contained monitoring unit, which are designed to operate in conjunction with

structurally separate data transmission and data display units. The contacts are positionable on the chest of a patient to receive electrical signals which are generated by the electrical activity of the patient's heart muscle. Electrical signals so received are transmitted to the monitoring unit for conversation to meaningful diagnostic data.

Specifically, the present invention recognizes that the ST segment of the heart muscle electrical signal, is a key indicator of myocardial ischemia. The ST segment of a typical healthy heart is a straight line of zero slope on or near a horizontal reference axis. If the ST segment is parallel to the reference axis, but is elevated or depressed by a significant deviation from the reference axis, the heart muscle signal is termed anomalous which may be indicative of an unhealthy heart muscle. Likewise, an ST segment exhibiting a significant positive or negative slope, may further be indicative of an unhealthy heart.

The monitoring unit of the present invention is provided with the requisite electronic circuitry and corresponding software to establish the reference axis for each signal, identify the ST segment of each such signal, and compare the ST segment with the reference axis. Accordingly, the monitoring unit measures the extent to which the ST segment deviates above or below the reference axis. This quantity, which is termed the measured ST deviation, is compared to a predetermined threshold deviation of the ST segment which is stored in the memory of the monitoring unit. When the monitoring unit first detects an ST deviation which exceeds the predetermined threshold ST deviation, the monitoring unit identifies this measured ST segment as an anomalous ST segment deviation initiating an ischemic event. The associated signal is then stored while the monitoring unit continues to search for further measured ST deviations exceeding the threshold ST deviation. Consecutive signals having ST deviations exceeding the threshold constitute an episode. For each episode, the monitoring unit records the first signal of the episode as noted above, the last signal of the episode, and the signal representing the maximum ST deviation of the episode, if there is such a maximum. To supplement these recorded signals, associated data such as slope of the ST segment, duration ,of the episode and heartbeat rate are also recorded. This data recording procedure is repeated for each occurrence of a new episode.

The recorded signals and associated data can be displayed by transmitting them from the monitoring unit to a remote display unit via a data transmission unit. Upon receiving the recorded signals and associated data from the monitoring unit for each episode, the display unit has the ability to print out the signals in graphical form along with the associated data in a summary report therewith. The display unit can be equipped to receive the output of a plurality of monitoring units from separate patients and from the same or different data transmission units. Each monitoring unit has a unique identification code which is transmitted to the display unit and displayed with the episode to identify the patient associated therewith.

The present device and method have a number of features which facilitate utility by a physician as a tool for the detection and diagnosis of existing or future heart problems. For example, the predetermined threshold ST deviation is adjustable by the physician and is advantageously set such that measured ST deviations greater than the predetermined threshold ST deviation reliably suggest a potential heart problem. The monitoring unit further provides pointers to be displayed with the printouts of the signals from the display unit which ensure the integrity of the data. A first pointer is provided to identify the point on the PR segment of each period which is used to establish the reference axis. A second pointer is provided to identify that point on each period of the ST segment where the actual ST deviation is measured. If a pointer is absent from a given period of a signal, it indicates that the monitoring unit was unable to determine the corresponding information for that period.

In further accordance with the utility of the present invention, the monitoring unit is designed to be portable. As a result, the mobility of the patient is not restricted by continuous use of the device throughout the patient's range of everyday activities. To facilitate portability, the monitoring unit is sized to affix to the patient and can be powered by a portable battery which has a long life of 96 hours or more due to power conservative operation of the monitoring unit. The data transmission unit can be maintained separate from the monitoring unit and coupled therewith only when downloading and display of recorded data is desired. Thus, portability of the monitoring unit is enhanced by its selective data transmission capability. Because the monitoring unit can operate independent of the transmission and display functions, the patient is not encumbered by the attendant equipment necessary to transmit and perform continuous data displays.

Finally, there is no practical limit to the data recording capabilities of the monitoring unit because, as noted above, it can be periodically downloaded to the data transmission unit whenever memory capacity is reached. Upon downloading, the memory of the monitoring unit is cleared and the unit is immediately available to resume monitoring the electrical signals of the patient's heart. This ensures that a continuous study of the patient's heart for a period of days or even weeks can

be performed without significant data storage restraints.

The novel features of this invention, as well as the invention itself, both as to its structure and its operation, will be best understood from the accompanying drawings, taken in conjunction with the accompanying description, in which similar reference characters refer to similar parts, and in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a plot of a normal heart muscle electrical signal;
Figure 2 is a plot of an anomalous heart muscle electrical signal;
Figure 3 is a schematic block diagram of the device of the present invention;
Figure 4 is a perspective of the monitoring unit in place on the body of a patient; and
Figure 5 is a plot of the ST trend diagram.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 graphically illustrates a single period of a typical normal heart muscle electrical signal **10** on a one millimeter square grid which is shown blown up here for clarity. The vertical scale of Figure 1 is the electrical force of the signal, wherein 1 millimeter = 0.1 millivolt. The horizontal scale is time, wherein 1 millimeter = 0.4 second. The reference axis **12** of the signal, which is conventionally termed the isoelectric line, is established by drawing a horizontal line of zero slope through the PR segment **14**. ST segment **16** is noted extending from the end of the S wave to the beginning of the T wave and for a typical healthy heart is characterizable as having zero slope and lying substantially on reference line **12**.

Figure 2 graphically illustrates a single period of an anomalous heart muscle electrical signal **18**. The anomalous curve **18** has substantially the same shape as the normal curve **10** of Figure 1, but the anomalous ST segment **20** is significantly depressed below the reference axis **22** of signal **18**. The distance **24** that ST segment **20** deviates from the reference axis **22**, either above or below, is termed the ST deviation. In the present case ST deviation **24** is a depression of about 1.5mm.

Figure 3 schematically shows the device of the present invention designated generally as **26**. Two pairs of conventional electrical contacts **28**, **30** are provided which attach to the skin on the chest **32** of patient **34**. Although two pairs of contacts **28**, **30** are shown here, it is understood that device **26** is operable with a single pair of contacts or any number of contacts greater than shown. The positioning of the contacts **28a**, **28b**, **30a**, **30b** is within the purview of the skilled artisan such that they are best able to receive the electrical signals of the heart muscle.

Each pair of contacts **28**, **30** is an electrical pick-up in communication with monitoring unit **36** via lines **38** and **40** respectively. Although contact pairs **28**, **30** are intended to detect the same heart muscle activity, each pair may measure a substantially different signal because of their different positions relative to the heart of patient **34**. Accordingly, lines **38** and **40** define separate data channels being fed to monitoring unit **36**. In the preferred embodiment, monitoring unit **36** is capable of processing a plurality of data channels separately. However, device **20** will be described hereafter in the context of a single data channel **38**, it being understood that the description of data channel **38** applies similarly to data channel **40** or any additional data channels which result when additional contacts are employed.

Monitoring unit **36** is provided with internal components which enable it to electronically process heart muscle electrical signals transmitted from contacts **28**, **30** and convert them into meaningful diagnostic data according to a method described hereafter. Internal components of monitoring unit **36** include an analog to digital converter **42**, a microprocessor **44**, and a memory **46**. A power pack **48**, which may be a conventional 9 volt battery, powers monitoring unit **48**.

Electrical communication is selectively provided between memory **46** of monitoring unit **36** and a data transmission unit **50** across a releasable linkage **52** such as an infrared optical coupling so that monitoring unit **36** and data transmission unit **50** can be maintained structurally separate. Data transmission unit **50** is provided internally with a memory **54** and a transmitter **56** which is preferably a telephone modem.

Data transmission unit **50** is in selective communication with display unit **58** via line **60** which is preferably a telephone line linkable to transmitter **56**. Display unit **58** is preferably a central processing unit (CPU) in command of conventional printers capable of generating strip recordings in the form of Figures 1 and 2 as well as associated data for compilation in a report. Display unit **58** may be further provided with a capability to transmit the reports via facsimile equipment to physicians' remote offices.

Figure 4 shows a preferred embodiment of the present invention as it is worn on the body of patient **34**. Monitoring unit **36** is housed within a self-contained enclosure **62** which is sufficiently small and lightweight to be portable. As shown herein, enclosure **62** is attachable to the patient **34** by a belt **64**. Alternatively, the enclosure **62** can be clipped to or inserted in the patient's clothing dur-

ing everyday use of the monitoring unit **36**. The monitoring unit **36** is intended to be continuously used in this fashion without substantially restricting the mobility or range of activities of the patient.

The method of operation of the present invention is now described in gross with reference to Figures 1-5. In operation, monitoring unit **36** is first positioned on the patient **34** by attaching contacts **28a**, **28b** to the chest **32** and attaching enclosure **62** to the patient **34** as shown in Figure 4. Referring back to Figure 3, line **38** is then secured between contacts **28a**, **28b** and monitoring unit **36**. Power is supplied to monitoring unit **36** from power pack **50**, placing unit **36** in an operational state.

When the myocardial cells of the heart muscle produce an electrical signal of the form as shown for example in Figure 1, the signal **10** is received by contacts **28a**, **28b** and transmitted via line **38** in an analog form to monitoring unit **36**. Analog to digital converter **42** digitizes the signal **10** and sends it to microprocessor **44** which establishes the reference axis **12** by locating the PR segment of signal **10**. Microprocessor **44** then locates the ST segment **16** of signal **10** and measures the ST deviation of the signal relative to the reference axis **12**. Since the ST deviation in Figure 1 is substantially zero, it does not exceed the threshold deviation. Therefore, signal **10** is not stored and monitoring unit **36** continues to receive the next signal for processing in this same manner.

If the next signal is of the form shown in Figure 2, a significant ST deviation **24** is detected by monitoring unit **36**. Microprocessor **36** compares measured ST deviation **24** to a fixed threshold ST deviation **66** which is predetermined and stored in memory **46**. Threshold ST deviation **66** is indicated by the horizontal dashed line in Figure 2. The threshold ST deviation is advantageously predetermined such that measured ST deviations greater than the predetermined threshold ST deviation reliably suggest myocardial ischemia. Thus, measurements of ST deviations exceeding the threshold serve as a notice to obtain close medical attention. For measuring depressions, a threshold ST deviation is generally preselected greater than about 0.5 mm, preferably greater than about 1 mm, and most preferably between about 1 and 1.5 mm below the reference axis **22**. In contrast, for measuring elevations, a threshold ST deviation is generally preselected somewhat higher than that for a depression. A typical threshold is on the order of about 2.0 mm.

Once monitoring unit **36** determines that signal **18** has initiated an event of interest, monitoring unit **36** stores signal **18** in memory **46** while microprocessor **44** receives consecutive subsequent signals.

If microprocessor **44** continues to measure deviations of subsequent consecutive signals which exceed the threshold deviation for an arbitrary preselected minimum time period (typically about 1 minute), the entire sequence of signals is designated an ischemic episode and the following data relating to the episode are retained in memory **46**: value of the reference axis, value of the threshold ST deviation, ST deviation of each signal, a separate strip (6 seconds in duration) for the signal initiating the episode, terminating the episode, and having the maximum ST deviation of the episode (if any), slope of the ST segments of the initiating, terminating and maximum signals, duration of the episode, and heart rate throughout the episode.

The data is retained in memory **46** until capacity is reached, at which time, monitoring unit **36** is removed from patient **34** and placed in communication with data transmission unit **50**. Memory **46** transmits data across linkage **52** to data transmission unit **50** which in turn stores the data in memory **54** for transmission by transmitter **56** to display unit **58**. Once memory **46** is downloaded, it is cleared, and capable of resuming data storage. Thus, monitoring unit **36** is returned to patient **34** at this time for continued operation.

Display unit **58** can produce all of the above recited numeric data in report form along with full print-outs of the six-second strips upon receipt from data transmission unit **50**. Additionally an ST trend plot shown in Figure 5 can be produced from a compilation of the ST deviation data for each signal. In the plot, the measured ST deviation is the vertical axis and time is the horizontal axis. The initiating ST deviation is denoted **24**, the maximum ST deviation is **68**, and the terminating deviation is **70**. It is apparent that the episode initiates and terminates at the threshold deviation **66**.

The above-described data recording procedure is repeated for each successive episode. The amount of data recorded in an episode or a series of episodes is not limited to the available memory **46** in monitoring unit **36** because of the downloading capability to transmission unit **50**. Therefore, continuous studies of the heart can be performed which exceed the limitations of the memory **46** in monitoring unit **36**.

In practice a number of additional operational features are built into the monitoring unit **36** which expand its data processing capabilities and insure the integrity of the data obtained thereby. Although microprocessor **44** has been described for simplicity as utilizing individual heart muscle electrical signals to establish when an ST threshold deviation is exceeded, in practice, an episode is not initiated until the average deviation of multiple consecutive signals exceeds the threshold deviation. By using the average, isolated aberrant or erroneous signal measurements are discounted. Thus, for example,

if measured ST deviation **24** was only a single isolated deviation, microprocessor **44** would recognize that no episode had occurred and eliminate the strip containing signal **20** from memory **46**.

Monitoring unit **36** also averages the QRS interval width of multiple signals in microprocessor **44** and uses this average to discard invalid signals. When microprocessor **44** identifies a signal with an excessive QRS interval width relative to the average, microprocessor **44** collects no further ST segment data on that signal. Other signal rejection criteria used by microprocessor **44** include excessively narrow signal, premature signal, reference axis wander, absence of R wave, or signal pause. Signals evidencing any or all of these characteristics are rejected and data recording does not resume until the signals stabilize. Similarly, if an ST segment is identified as having an excessive slope, that segment will be rejected from the collected data.

The monitoring unit **36** has been described above for operation in an automatic mode. However, patient **34** can activate the ST segment data acquisition and recording function of monitoring unit 36 at any time he or she is symptomatic. Referring to Figure 4, patient **34** can record a strip without monitoring unit initiation simply by depressing an activation button **72** on enclosure **62** in communication with microprocessor **44**. When the strip is displayed by unit **58**, it is identified as resulting from patient activation.

Enclosure **62** is further shown in Figure 4 having two external switches **74**, **76** on its face which are in communication with microprocessor **44**. Switches **74**, **76** may be set by patient **34** or a physician to manually specify operating parameters of the monitoring unit **36**. Specifically, dip switch **74** is provided to manually select between a plurality of time points after the S wave terminates at which to measure the ST segment deviation. In the preferred embodiment, ST deviation can be measured at either 60 or 80 milliseconds after termination of the S wave.

Switch **76** provides for one of two modes for establishing the threshold ST deviation. In the first mode, i.e., the absolute mode, the threshold deviation is set at a fixed value which is projected to be indicative of ischemia. In a preferred embodiment, switch **76** has the setting options of 1.0 and 2.0 mm for ST depression and 1,2,3 or 4 mm for ST elevation. The settings are selected on the basis of the patient's individual signal characteristics. In the second mode, i.e. the delta mode, the value of the threshold deviation for ST segment depression is allowed to float as a function of a patient's computed normal depression. Thus, if a patient consistently indicates an ST depression of 0.5 mm and switch **76** setting is on 1.0 mm in the delta mode, the threshold depression which will initiate an episode is 1.5 mm.

To enhance data integrity, warnings are provided to patient **34** when maintenance of device **26** is required. Monitoring unit **36** has an audible alarm (not shown) and a visual display **78** such as an LCD in enclosure **62** shown in Figure 4 which indicate when power pack **50** shown in Figure 3 is low, input signals from contact pairs **28**, **30** are lost, or memory **46** is full. Likewise, data transmission unit **50** is provided with an alarm to indicate if data transfer from monitoring unit **36** or to display unit **58** is malfunctioning.

When power pack **50** is low, microprocessor **44** blocks operation of the monitoring unit **36** to prevent loss of data until power pack **50** is replaced. Furthermore, memory **46** cannot be accessed until this condition is corrected. An additional long life power backup **80** is provided to memory **46** in the event of complete power failure or during changing of power pack **50** to ensure that no data is lost. A preferred backup is a lithium battery having a battery life of many years.

Pointers **82**, **84** shown on Figure 2 are provided by microprocessor **44** with strip data to enable validation of the reference axis **22** and ST segment deviation **24** measuring points respectively. Pointers **82**, **84** are printed directly on the strip when produced by display unit **58**.

While a particular Device for Detecting Abnormal Heart Muscle Electrical Activity as herein shown and disclosed in detail is fully capable of obtaining the objects and providing the advantages herein before stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction or design herein shown other than as described in the appended claims.

Claims

1. An apparatus for monitoring heart muscle electrical activity of a patient characterised by comprising:

   means positionable on the body of a patient for receiving electrical heart muscle signals generated by the patient;

   means for establishing a reference axis relative to each of said signals;

   means for identifying an ST segment in each of said signals;

   means for measuring an ST deviation from said reference axis of each said ST segment and comparing said ST deviation to a predetermined threshold ST deviation; and

   means for storing an anomalous ST deviation exceeding said predetermined threshold

ST deviation.

2. An apparatus according to claim 1 characterised in that said measuring means is further for determining an average ST deviation from a plurality of said ST deviations in sequence and for comparing said average ST deviation to said predetermined threshold ST deviation and wherein said storing means is further for storing a plurality of anomalous ST deviations in sequence having an average ST deviation exceeding said predetermined threshold deviation to the exclusion of ST deviations having an average ST deviation below said predetermined threshold ST deviation.

3. An apparatus according to claim 2 characterised in that said storing means is further for storing a first signal and a last signal of a sequence of heart muscle electrical signals embodying said plurality of anomalous ST deviations in sequence to the exclusion of signals embodying ST deviations having an average ST deviation below said predetermined threshold ST deviation.

4. An apparatus according to claim 3 characterised in that said storing means is further for storing a signal corresponding to a maximum ST deviation of said sequence of heart muscle electrical signals embodying said plurality of anomalous ST deviations in sequence.

5. An apparatus according to any one of the preceding claims characterised in that said measuring means is further for measuring a heart rate time history of said patient while measuring said plurality of anomalous ST deviations in sequence and wherein said storing means is further for storing said heart rate time history.

6. An apparatus according to any one of the preceding claims characterised by further comprising means for displaying said stored ST deviation exceeding said predetermined threshold ST deviation and means for transmitting said stored ST deviation from said storing means to said display means.

7. An apparatus according to claim 2 characterised by further comprising means for displaying said stored plurality of anomalous ST deviations in sequence on a plot versus time and means for transmitting said plurality of anomalous ST deviations in sequence from said storing means to said display means.

8. An apparatus according to claim 3 characterised by further comprising means for displaying said first signal and said last signal of said sequence of heart muscle electrical signals embodying said plurality of anomalous ST deviations in sequence and means for transmitting said first signal and said last signal from said storing means to said display means.

9. An apparatus according to any one of the preceding claims characterised in that said measuring means is further for measuring a slope of said ST segment relative to said reference axis.

10. An apparatus according to any one of the preceding claims characterised by comprising:

a plurality of electrical contacts positionable on the body of a patient to receive electrical heart muscle signals generated by the patient; and

a monitoring unit having a microprocessor in electrical communication with said plurality of electrical contacts to establish a reference axis relative to each of said signals, to identify an ST segment in each of said signals, to measure an ST deviation from said reference axis of each said ST segment, and to compare said ST deviation to a predetermined threshold ST deviation, said monitoring unit further having a memory to store an anomalous ST deviation exceeding said predetermined threshold ST deviation.

11. An apparatus according to claim 10 characterised by further comprising:

a data transmission unit in selective communication with said monitoring unit, said data transmission unit having a memory to receive said stored anomalous ST deviation from said memory of said monitoring unit and having a modem to transmit said stored anomalous ST deviation;

a telephone line; and

a remote central processing unit in selective communication with said modem across said telephone line for receiving said stored anomalous ST deviation and having printing means for displaying said stored anomalous ST deviation.

12. An apparatus according to claim 10 or 11 characterised in that said monitoring unit is self-contained and further is portable and affixable to the patient.

13. A method of employing a portable monitoring

unit for monitoring heart muscle electrical activity, the method being characterised by comprising:

obtaining electrical heart muscle signals and transmitting said signals to said monitoring unit;

establishing a reference axis relative to each of said signals by means of said monitoring unit;

identifying an ST segment in each of said signals by means of said monitoring unit;

measuring an ST deviation from said reference axis for each said ST segment and comparing said ST deviation to a predetermined threshold ST deviation by means of said monitoring unit; and

storing an anomalous ST deviation exceeding said predetermined threshold ST deviation by means of a memory within said monitoring unit.

14. A method for monitoring heart muscle electrical activity according to claim 13 characterised by further comprising determining an average ST deviation from a plurality of said ST deviations in sequence and comparing said average ST deviation to said predetermined threshold ST deviation within said monitoring unit, and storing a plurality of anomalous ST deviations in sequence having an average ST deviation exceeding said predetermined threshold deviation in said memory of said monitoring unit to the exclusion of ST deviations having an average ST deviation below said predetermined threshold ST deviation.

15. A method for monitoring heart muscle electrical activity according to claim 14 further comprising storing a first signal and a last signal of a sequence of heart muscle electrical signals embodying said plurality of anomalous ST deviations in sequence in said monitoring unit of said memory to the exclusion of signals embodying ST deviations having an average ST deviation below said predetermined threshold ST deviation.

16. A method for monitoring heart muscle electrical activity according to claim 13 or 14 characterised by further comprising downloading said memory of said monitoring unit into a memory of a data transmission unit, transmitting said plurality of anomalous ST deviations in sequence from said memory of said data transmission unit to a remote display unit, and creating a graphical display of said plurality of anomalous ST deviations versus time.

17. A method for monitoring heart muscle electrical activity according to claim 15 characterised by further comprising downloading said memory of said monitoring unit into a memory of a data transmission unit, transmitting said first and second signals from said memory of said data transmission unit to a remote display unit, and creating a graphical display of said first and second signals versus time.

18. A method for monitoring heart muscle electrical activity according to claim 17 characterised by further comprising labelling with respect to each said first and last signals a first time point on said graphical display where said reference axis is established and a second time point on said graphical display where said ST segment deviation is measured.

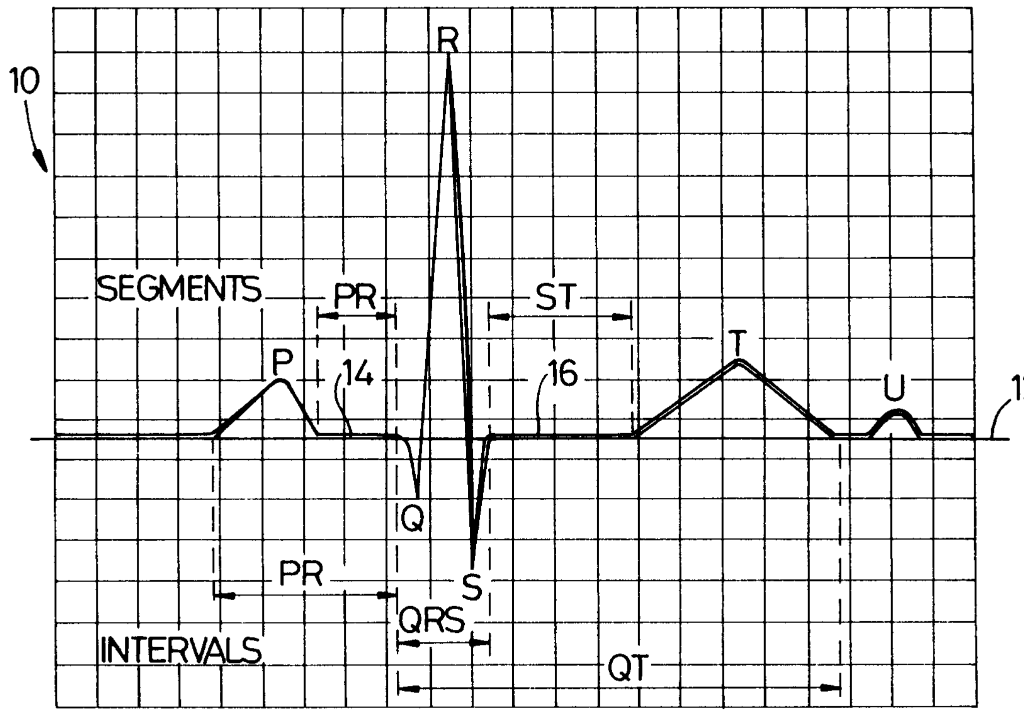
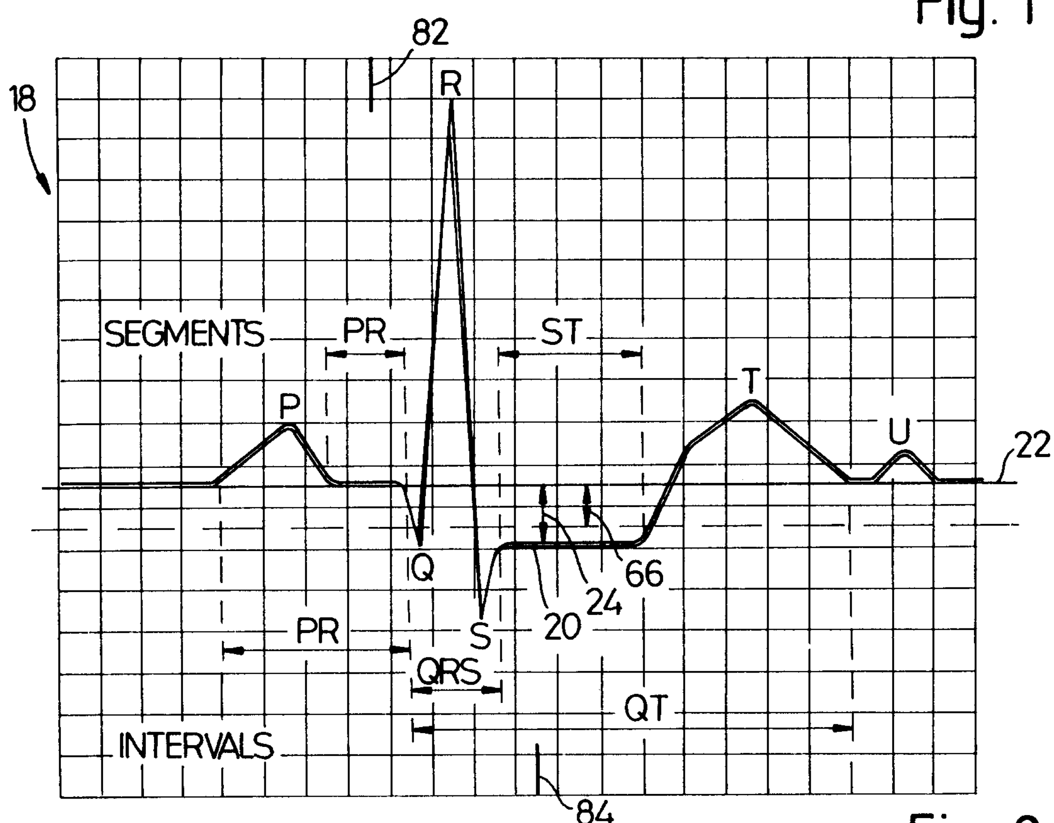

10
R
SEGMENTS
PR
ST
P
14
16
T
U
12
Q
S
PR
QRS
INTERVALS
QT

Fig. 1


82
18
R
SEGMENTS
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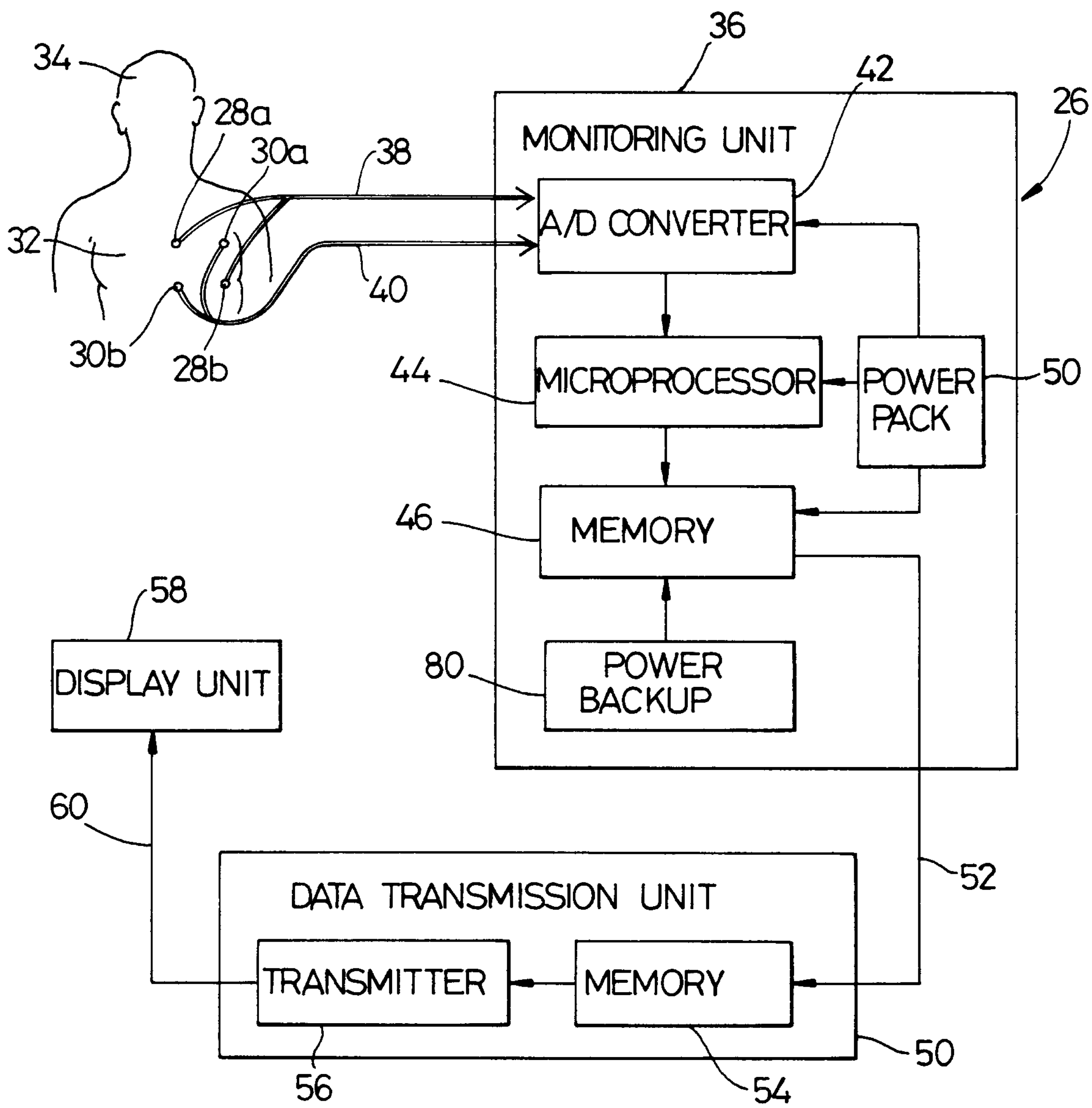
QRS
QT
INTERVALS
84

Fig. 2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30a
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32
40
30b
28b
36
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A/D CONVERTER
44
MICROPROCESSOR
POWER PACK
50
46
MEMORY
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POWER BACKUP
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DISPLAY UNIT
60
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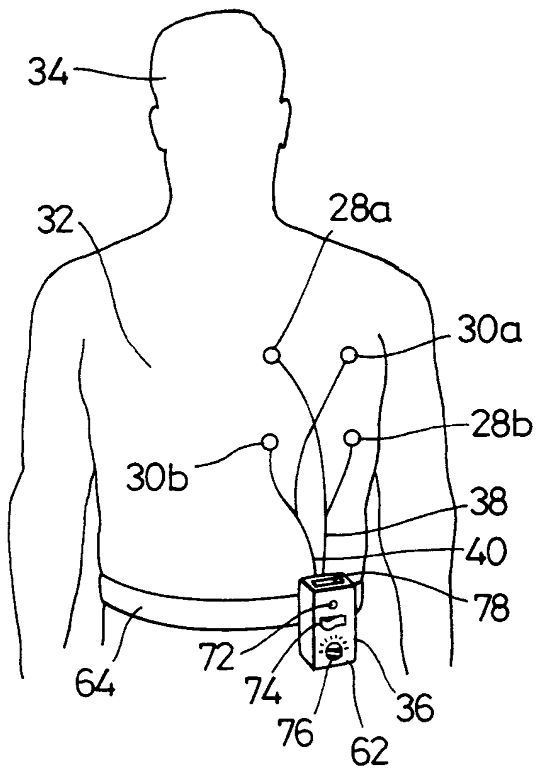
DATA TRANSMISSION UNIT
TRANSMITTER
MEMORY
50
56
54

Fig. 3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30a
28b
30b
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72
64
74
76
62
36

Fig. 4

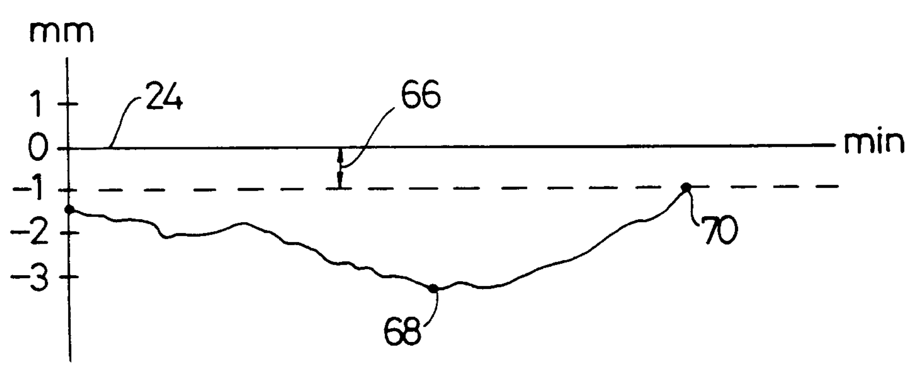
mm
1
0
-1
-2
-3
24
66
min
70
68

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0769

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 930 075 (KORTAS)	1	A61B5/0452 A61B5/0432 A61B5/00
	* the whole document *		
A		9,10,13	

Y	IEEE COMPUTERS IN CARDIOLOGY. September 1985, US pages 229 - 232; JENKINS ET AL.: 'Automated arrhythmia analysis combined with st analysis for exercise monitoring.' * the whole document *	1,10,13	
A		2,6-9, 14,16-18	

Y	WO-A-8 303 744 (REINHOLD ET AL.) * page 14, line 3 - page 55, line 2 * * figures 1-5 *	1,10,13	
A		2,4-6, 11,12,16	
	---		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 822 696 (EKSTROM ET AL.) * the whole document *	1,2,5, 10,11,14	A61B A61N G06F

A	EP-A-0 209 804 (ROSSI) * page 2, line 24 - page 11, line 29 * * figures *	1,2,6,7, 10-14, 16,17	

E	EP-A-0 472 411 (NAPPHOLZ ET AL.) * column 9, line 51 - column 26, line 5 * * figures 1-11 *	1,2,6,7, 9-14,16, 17	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 JULY 1992	CHEN A.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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